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Abstract:
Discusses the relation between cybernetics and architecture and pays tribute to Gordon Pask's role and influence. Indicates Pask's contribution to an increasingly environmentally responsive architectural theory that may lead to a more humane and ecologically conscious environment.

Introduction

At the time of starting to write this essay from Hong Kong, 30 June 1997, on the cusp of the return of the city state to China, there is intense world wide activity in architecture which in some way acknowledges a debt to cybernetics. Thus at least one aspect of Gordon Pask's influence on the development of architectural theory has come to fruition.

One of the major catalysts for this activity was the exhibition "An evolutionary architecture" at the Architectural Association (AA) in London in January 1995. This was part of an experimental project at the AA from 1989 to 1996 involving my postgraduate students. Cybernetics was central to this project and Gordon played a role in this adventure, tutoring my students right up to his death in 1996.

The exhibition stretched back to the 1960s when I was a student at the AA and the role of cybernetics in architecture was just beginning to be acknowledged. Right from the outset Gordon Pask was a source of inspiration and soon became directly involved. This essay establishes the background in the speculative ideas of the 1960s and illustrates their realisation in a project of global significance in the 1990s. It pays tribute to Pask's role and influence, and indicates his contribution to an increasingly environmentally responsive architectural theory that may lead to a more humane and ecologically conscious environment.

Background

To understand why Gordon Pask was involved with my architectural students on this seven year research project, it is first necessary to explain about the connection between architecture and cybernetics and to indicate Gordon's contribution.

The environment for this fruitful interaction between architecture and cybernetics was the AA. Founded in 1847 by apprentices who were disillusioned with their education, the AA provided a self-directed, independent school for architects before any formal training for the profession existed outside the apprenticeship system (Summerson, 1947).

The AA has miraculously survived 150 years as a vibrant, anarchic and independent institution. The methods of education are continually evolving and are imitated all around the world but equalled nowhere. As a fascinating educational experiment, it attracts international staff and students. As a leading architecture institution, it exerts a global influence in the field through its exhibitions and publications (Gowan, 1975).

Avant-garde architectural thinking in the 1960s was preoccupied with issues of flexibility, impermanence, prefabrication, computers, robotics, and a global approach to energy, resources and culture. The implied systems thinking in architecture inevitably came to embrace cybernetics and cybernetics in architecture inevitably came to embrace Gordon Pask. Gordon found the AA to be a sympathetic environment, the AA warmed to Gordon and the fertile relationship extended for the next 30 years.

Involvement in architecture

In 1960 Gordon extended his involvement to architectural projects when he was invited to become a consultant to the Fun Palace. This was a visionary project conceived of and designed by the architect Cedric Price for Joan Littlewood. The design provided a highly flexible indeterminate space capable of responding to users and enabling a wide range of activities (Landau, 1968).

Whilst mainstream architectural practice was still largely concerned with modernism, these new preoccupations of indeterminacy and interactivity achieved recognition by the mid 1960s in the more enlightened mainstream architectural press and in particular Architectural Design under the imaginative editorship of Monica Pidgeon.

A special issue of Architectural Design in September 1969, with guest editor Roy Landau, carried contributions by Imre Lakatos, Warren Brodey, Karl Popper, Cedric Price, Andrew Rabeneck, Lancelot Law Whyte, Nicholas Negroponte, Stanford Anderson and Gordon Pask.

In his article, “The architectural relevance of cybernetics”, Gordon claims that architecture and cybernetics share a common philosophy of architecture in the sense that Stafford Beer had shown it to be the philosophy of operational research. The argument rested on the idea that architects were “first and foremost system designers who had been forced to take an increasing interest in the organisational system properties of development, communication and control”. Gordon identified a significant vacuum in architectural theory and claimed cybernetics as “a discipline that fills the bill insofar as the abstract concepts of cybernetics can be interpreted in architectural terms (and, where appropriate, identified with real architectural systems) to form a theory (architectural cybernetics, the cybernetic theory of architecture)” (Pask, 1969).

Gordon’s analysis of the history of the development of architectural theory dismisses theory before 1800 as existing only as an “abstraction from the art of building”. Problems could be solved by the judicious application of architectural rules. Consequently architects did not need to see themselves as system designers even though they designed systems. Gordon suggests that the new building problems posed by the Victorian era could no longer be solved in this way. Novel techniques were developed (Gordon cites Temple Meads, the Tropical House at Kew and the Crystal Palace) and these were clearly examples of system design although there was no theory for this new architecture.

The article goes on with an analysis of functionalism and embraces architectural holism, evolutionary ideas, symbolic environments, the machinery of architectural production and the widening brief. He establishes that there is a demand for system oriented thinking whereas in the past there had been only a more or less esoteric desire for it. He cites Nicolas Negroponte and the Fun Palace project with Cedric Price (modestly omitting to mention his own role in the project).

Thus cybernetics in architecture is advanced as a new theoretical basis and as a metalanguage for critical discussion. Additionally cybernetics is advanced for its predictive power and urban development can be modelled as a self organising system. Explanatory power is also claimed for the ability to mimic certain aspects of architectural design by “artificial intelligence computer programs”.

Although Gordon is talking about responsive environments in a dynamic sense he cites Antonio Gaudi’s Parque Guell as, at the symbolic level, “one of the most cybernetic structures in existence … your exploration is guided by specially contrived feedback” although the building is a physically static structure (the dynamic process depending on the movement of people or shifts in their attention)”.

The article closes with “a simple cybernetic design paradigm” which ends by turning the adaptive and interactive paradigm back on itself and applying it to the interaction between the designer and the system he designs, rather than the interaction between the system and the people who inhabit it. Overall, the article is extraordinary in its grasp of the current architectural dilemma and in its identification of a vacuum in contemporary theory.

Towards a realisation

During the difficult mid 1970s to mid 1980s Gordon Pask was increasingly involved in architectural and design education but it was not until the late 1980s that Gordon was appointed to the AA staff on a regular basis. By this time microprocessors had developed to a point when many ideas from the 1960s were now achievable. The theoretical position had also developed and was enriched by other ideas from biology and the physical sciences. Professional mainstream architecture had lost both its own confidence and public credibility and was searching for new directions again. At the end of the 1980s Gordon was finally able to make a significant contribution where much of the thinking started in the 1960s and had now reached a point of seeing real application in the built environment.

The seven year morphogenesis project: 1989-1996

A postgraduate level project (diploma level unit in AA jargon[1]) was established in 1989 dedicated to the investigation of morphogenesis and to the exploration of the uses of machine intelligence in architecture. This led to the proposition of an evolutionary architecture (Frazer, 1995a; Frazer and Frazer, 1996).

At the outset the investigations were concerned with the implications of rule-based generative systems. Emphasis was placed on the intelligent processes underlying design thinking with the intention of developing approaches to architecture where the rules are so configured that the program itself could take over the evolution of the design. There were investigations of cellular automata, stochastic and heuristic programming, learning and morphological programs, fractals and parallel processing.

In the Projects Review for this year there is a photograph of Gordon standing with the "Universal Constructor" which was a substantial re-configurable model which solicited interaction by flashing a multitude of LEDs which indicated one of 264 states for each cell in a 12 by 12 by 12 array. A problem could be set to the constructor by physically reconfiguring the cells which were machine readable for location and state. The Universal Constructor (in deference to von Neumann) was then able to respond on a rule-based system; for example, constructing a three-dimensional self-replicating automata in response to an obstacle (Frazer et al., 1990; Twinch, 1990).

In the following year the students involved in this project were under increasing pressure to demonstrate the applicability of the work so a series of probes and incursions were formulated. Investigations into the fundamental processes of form generation continued with examinations of non-deterministic systems, positive and negative feedback, neural networks, direct mental input, co-operative and social computing and genetic learning programs. Projects included the building of new design tools, and making models of intelligent responsive systems. The intention was to explore beyond an algorithmic approach to generative and self-organising architecture and to investigate systems which learned on the basis of feedback (Frazer et al., 1991).

For the end of the academic year in 1992 an exhibition was planned around the theme of antennae. The production of form in response to environmental and cultural conditions was investigated through the development of interactive probes and sensory devices. Antennae were developed for the reception and transmission of information. All the antennae communicated through a central rack of circuit boards – the "Interacktor". The communication between devices was controlled by a genetic algorithm which modified the program according to ability to produce an appropriate response to the environmental conditions (Frazer et al., 1992).

In the following year both practical and theoretical aspects of fundamental form generating processes, natural and artificial, were explored. Solar geometry was selected to demonstrate the form influencing effects of just one environmental factor considered in isolation. A number of new tools for both the explanation and calculation of solar geometry were developed and patented. The potential for these techniques was demonstrated with the development of a responsive skin for a building in Kuala Lumpur. Theoretical work advanced with the development of a new computer datastructure for the storing and manipulation of genetic design information packed into a "seed" to provide the mechanism for scale change and materialisation in the real world (Frazer et al., 1993).

By 1993 we were ready to propose and demonstrate the notion of a genetic language of architecture. Work on living systems and artificial life led to the development of a set of codescripts for the evolution of structure and form and a genetic architectural language for encoding them. The computer model was now developed to the point where it was able to execute a form generating process in a simulated environment. Evolutionary space and time were compressed so that the model could evolve over a large number of iterative cycles. The theoretical framework had now been developed to the point where it could be demonstrated interactively (Frazer et al., 1994).

The end of the first five-year phase of the project was celebrated in January 1995 by the publication of the book, An Evolutionary Architecture (Frazer, 1995a), a simultaneous exhibition and the launch on the Internet ofanexperimental evolutionary environment, which attracted global participation. The book and the exhibition marked a crucial transition from developing theoretical models to an investigation of a process-driven materialisation.

Gordon wrote the foreword to the book and in addition to his generous and perceptive analysis of the thesis also commented on the working method of the project in the context of the universal constructor:

However it is appropriate to stress an important cybernetic feature of the work; namely, that unity is not uniformity, but is coherence and diversity admixed in collusion. In the context of a study unit at the AA, for example, the very liberal project brief allows individuals to pursue apparently divergent interests of their own: coherence is provided by commonly accessible resources such as "the Universal Constructor". The result is the encouragement of originality by even more subtle means (Pask, 1995).

The exhibition and co-operative evolution on the Internet

For the exhibition in January 1995 we constructed "An evolutionary architecture" for the Architectural Association Gallery in London. The centrepiece to the exhibition, "The Interactivator", as an evolving environment which was planned to respond to both interaction from the exhibition visitors and the atmosphere in the exhibition space. Visitors were to interact by proposing genetic information which would influence the evolution of the model. Sensors in the exhibition space also affected the evolution of the model with data on temperature, humidity, noise, smoke and so forth. We extended this concept to allow co-operation on the Internet in three ways:

(1) by using the Internet to allow virtual visitors to input genetic informarpar; by allowing the program of the model to be downloaded to remote sites so that it replicated itself and each replication took on a divergent evolutionary path, the results of which could also be fed back to the central model to contribute to the gene pool; and
(3) by allowing access to the exhibition and the book via a conventional Web site so that the context could be understood and the stages in the development of the evolving model could be observed (Frazer et al., 1995a; 1995b).

The exhibition installation and virtual visitors

For the exhibition installation three interlinked computers were in use. The central machine handled the evolving model and displayed a rendered visualisation of the developing cell structure and a representation of the landscape of the genetic search space. One computer handled communication with the outside world and received input from the environmental sensors in the exhibition space, input from gene switches for visitors to experiment with, output sound generated by the system and was directly connected to the Internet to receive and transmit genetic information. The third computer generated images of the emerging forms and provided an animation of the growth and development of the model[2].

Virtual visitors could view the current state of the model and receive an explanation, or they could participate by providing genetic or environmental information. For real enthusiasts, copies of the software were available for downloading. Feedback from remote copies of the software also affected the source model.

In the first two weeks after the launch of the model it evolved four family members based on the chromosomes received and those bred internally, each member achieving chromosomal stability in about 120 generations. Though it is impossible to predict the nature of the model, or its evolving internal logic, there seems to be a pattern emerging towards its selective and hence, evolutionary process.

With the assistance of Ellipsis publishers the virtual version of the exhibition was launched on the Internet in January 1995. The central model convincingly demonstrated the principle of evolving a structure under the influence of both public participation and environmental information. But the rate of change was too slow to give any indication of how any individual was affecting it, and the feed back to the Net was never properly implemented to show any development. Downloading the model to remote sites revealed all manner of technical problems which meant that biodiversified genetic material never found its way back to the central model. The Ellipsis site was labyrinthine which delighted many visitors but frustrated others who never found how to input genetic information. Overall the experiment attracted a great deal of interest and comment, both on the Net and in the press including features in Wired and Architectural Design (Astragal, 1995; Bettum, 1995; Brown, 1995; Evans, 1995; Frazer, 1995a; 1995b; Kunzru and Search, 1995).

The realisation of the idea

In its first five years the unit developed a theoretical framework and a model of an alternative generative process. By using the computer to compress evolutionary space and time, the model could be evolved over large numbers of iterative cycles. The theoretical framework was developed to the point where a prototype can be demonstrated interactively: a dematerialised model had been established (Rastogi, 1996).

Thus 1994/1995 became a pivotal year. Up to that point the project had been modelling the inner logic of form-generating processes rather than the external form itself. The new phase concentrated on the externalisation of this conceptual model into constructed form by material generating processes. The approach included the study of formative processes in both natural and industrialised production. This started a new synthesis of information and formation.

The next phase of the programme focused on the externalisation of the conceptual model into constructed form by concentrating on urban scale evolution and other historical and natural examples of co-operative and ecologically integrated development. This was approached by considering the metabolic processes as a way of understanding both the formal development of urban symbiosis as well as the specific problem of materialisation. Urban scale evolution was studied through historical and natural examples of co-operative and ecologically integrated development. The approach was to consider the metabolic process as a means of understanding the formal development of urban symbiosis. As a demonstration a prototype experimental interactive, evolving computer model was commissioned by Groningen city planning department (Frazer, 1996a; 1996b).

The Groningen experiment

The objective was to produce a small working prototype demonstration of a predictive urban computer model, which models not so much what is, but what might be. An evolutionary model which explains the transition from the past to the present and projects trajectories for future possibilities. A “what if” model for generating and exploring alternative futures and evaluating them. A generative model that can mediate in scale, space, and time: in scale, between the urban context and the fine grain of the housing typologies. In space, between the existing fabric of Groningen and specific dwelling units. In time, between the life style of the medieval core and the future desires of the citizens of the next century (Schmitt, 1995).

Particular features of this prototype were that it combined generative (cellular automata) techniques and learning (genetic algorithm) strategies, to produce a rule-based system which learns on the basis of feedback from the inhabitants.

The structure for the model

Central to the Groningen model (Plate 1) is the idea that the computer program inhabits an environment, enters it, reads it, understands its developmental rules and history, grasps its topography, latitude and climate, models its society and economy. The program then starts to solicit suggestions and make proposals for possible features.

The model becomes an inhabitant. It maintains a discourse with other, human inhabitants and tries to understand and interpret their desires, aspirations, urges, expectations, and reactions to their existing environment and projected future environments. On the basis of this interaction with the actual inhabitants, the virtual Inhabitor patiently modifies its criteria for evolutionary development and selection, endlessly repeating the process of refining and modelling prototypical futures. As it does so, it occasionally produces experimental genetic mutations or amplifies variety.

The Inhabitor models the desires, aspirations, urges, expectations, reactions of the inhabitants to their environment and projected new environments.

The Inhabitor can inhabit at any level: cell, room, house, district, city, regions, continent and planet. It can also inhabit past environments, present environments and possible re-inhabitation of past and present habitats, and from the interaction of citizens who provide feedback tendencies and selection criteria.

The core of the Inhabitor is the Evolver, an evolving genetic model in which the isospatial datastructure and genepool are controlled by genetic algorithms. The Evolver is a recursively self-similar program which employs the same strategies at each level of interaction. It provides starting configurations or seeds for genetic algorithms, which learn on the basis of feedback from specific sites. The criteria for genetic selection are determined by citizen interaction with the Enabler.

The Enabler has connections to an interactive map (input desire lines, etc.) and an active output model. This is the basis for dialogue between the virtual Inhabitor and the real inhabitants.

A self-similar datastructure models the environment at the regional, urban, district and site scales (part of a continuum of scales, from global down to cellular). The datastructure is strategically modular without being geometrically constrained to modularity. It can interact with other sites at the same level, or with other levels, either top down or bottom up. Using specific data (GIS), these levels are mapped to specific situations and respond to exogenous influences. In the case of Groningen, the demonstrations are at the level of the local topography, the city form, the Ooesterhamrick district and the Ciboga site. Generative modellers actively generate new possibilities from inputs to the Evolver. In turn, feedback from the specific sites affects the selection processes in the Evolver.

To paraphrase Stafford Beer, “The public is conceived as a system, a model of which is contained in the computer. The public supplies minimal information, which the computer then synthesises in the model. This amplifies variety as required to help the public and attenuates variety to help the manager – thereby meeting the requirement of the law of requisite variety for each of them”.

This experiment went some way to realise, through the medium of modern digital technology, the preoccupation of Patrick Geddes that the ordinary citizen should have a vision and a comprehension of the possibilities of his own city. The experiment addressed the need for and value of “citizen participation” in town planning. It also demonstrated the need for a Civic Exhibition and a permanent centre for Civic Studies in every town – an “Outlook Tower”. By providing appropriate modes of interaction and feedback, we proposed that the bars and cafes of Groningen should be the Outlook Towers of the future[3] (Frazer, 1997).

Gordon died shortly before the project was successfully demonstrated in both Groningen and London in June 1996. With the permission of Liz Pask, the book of the project, The Groningen Experiment, is to be dedicated to the memory of Gordon Pask in recognition of his inspiration and involvement.

Notes

1. The unit (referred to in the catalogues as unit 14 in 1989/1990 and thereafter as unit 11) was started by John Frazer and Julia Frazer assisted by Pete Silver from 1989 to 1994 and from 1994 to 1996 by Guy Westbrook. The unit became replicated in 1995 at the Bartlett School of Architecture, University College London, when Pete Silver left to start his own unit 14 based on these same ideas.
2. Although it is no longer possible to interact with the Interaktor it can still be viewed at: http://www.gold.net/ellipsis/evolutionary/evolutionary.html
3. The project can be glimpsed at Transarchitectures 02, Cyber-espaces et Théories Emergentes, available at: http://www/epita.fr/nouvel_b/transarchitectures02/

Plate 1. Project by Orit Kaufman, AA student of John Frazer and tutored jointly with Gordon Pask 1995/1996. Diffusion aggregate computer model for Groningen model resulting from studies of dendritic growth inspired by Gordon’s chemical computer experiments (this was the last student project to be tutored by Gordon Pask)

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